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Materiel Test Procedure 2-3-516
U. S. Army Armor and Engineer Board

U. S. ARMY TEST AND EVALUATION COMMAND
COMMON SERVICE TEST PROCEDURE

HUMAN FACTORS ENGINEERING

1. OBJECTIVE

The objective of this Materiel Test Procedure (MTP) is to outline procedures for determining the adequacy of the human factors engineering (HFE) aspects of the test item, and its compatibility with the skills, aptitudes, and limitations of personnel who will use, operate, and maintain the item.

2. BACKGROUND

Effective use of military equipment is contingent upon its design and the operational capability of the user. The ability of men to operate equipment, together with the quality of equipment performance, accounts for the capability and efficiency of the entire system. As a consequence, equipment should be designed and placed in an environment that is suitable and practical for personnel who are responsible for its operation and maintenance. Merging of personnel with the environment often gives rise to the problem commonly encountered in the discipline of human factors engineering, namely, to define a suitable environment. That defining a suitable environment is not easy is validated by the fact that a man's opinion in one set of circumstances may be quite different in another set of circumstances. For example, a man with a headache may say his working environment is intolerable; free from pain, he may say his working environment is excellent. Furthermore, as both statements may be correct, this example points out the fact that opinions expressed can be strongly influenced by the sense of well-being at the time his decision is made. Another difficulty encountered in defining a suitable environment is attributable to differences between men. For example, a small man may move freely and perform well in a space which a large man finds unbearable, or one man may be able to sit motionless for hours without any apparent discomfort while this same inaction may drive another man to distraction. From these examples it is readily apparent that definition of a suitable environment must account for two factors - differences within personnel and differences between personnel.

Human factors engineering attempts to treat both differences within and between personnel by statistical methods. That is, elimination of differences within personnel is accomplished by recording the opinions of one man over a long period of time and compiling a composite opinion which more or less represents his average opinion; whereas elimination of differences between personnel is accomplished by recording the opinions of many men and compiling a composite opinion which more or less represents their average opinion. Physical differences between personnel are usually given primary consideration in the design of materiel despite the fact that differences within personnel may be more important under stress of combat.

Many compromises with established standards of comfort, performance, and maintenance may be necessary to produce a practical item that is capable

of fulfilling its military goals. This is true particularly in such areas as noise and vibration in tracked vehicles. The service test is the first time that the equipment is operated by soldiers under simulated combat conditions. This is the time when the final determination is made concerning man-equipment compatibility.

3. REQUIRED EQUIPMENT

Human factors engineering evaluation will normally not require any special tools, equipment and test sites other than those required by the applicable commodity MTP for the equipment under test. When directed by the project officer instruments, as required for specific monitoring functions, shall be installed.

4. REFERENCES

A. USATECOM Regulation 385-6, Verification of Safety of Materiel During Testing.
B. Human factors engineering portions of the QMR, SDR, or technical characteristics (TC) for the test item.
C. Human Factors Engineering Requirements for the Development of U. S. Army Materiel, Aberdeen Proving Ground, Maryland, HEL Standard S-4-65, January 1965 or later version.
D. Human Factors Engineering Design Standard for Vehicle Fighting Compartments, Aberdeen Proving Ground, Maryland, HEL Standard S-2-64, May 1964 or later version.
E. Human Factors Engineering Design Standard for Wheeled Vehicles, Aberdeen Proving Ground, Maryland, HEL Standard S-6-66, September 1966 or later version.
F. Human Factors Evaluation Data for General Equipment (HEDGE) and Guidebook Supplement by U. S. Army General Equipment Test Activity, November 1967.
G. MTP 2-3-506, Simulated Tactical Operation.
H. MTP 10-3-501, Operator Training and Familiarization.

5. SCOPE

5.1 SUMMARY

This MTP describes the procedures for evaluating the human engineering aspects of equipment design with respect of conditions which will reduce operational effectiveness.

a. Preparation for Test - Procedures for training and familiarizing of personnel and preparation of a data collection plan.
b. Test Conduct - An evaluation in conjunction with each phase of operational testing and maintenance of the test materiel to locate and correct man-machine incompatibilities.

5.2 LIMITATIONS

This MTP is limited to the detection of man-machine problem areas that can be accomplished without instruments or with instruments which can be installed and/or monitored by personnel expected to operate and maintain the equipment. If instruments are used they should not degrade equipment performance or interfere with normal duties of personnel.

6. PROCEDURES

NOTE: Human factors engineering evaluations, if carried out to the nth degree on each component or part of an item of equipment, could consume a large portion of the time allotted for service testing. In addition, the instrumentation and levels of technical skills required would be beyond those normally found at a service test activity. Therefore, guidance in this MTP is directed primarily toward the action to be taken on man-machine incompatibilities detected while operating, maintaining, occupying, or otherwise utilizing the test item.

6.1 PREPARATION FOR TEST

6.1.1 Safety

The project officer should ensure that a safety release in accordance with reference 4A has been received from HQ USATECOM and is understood before test is started and that any limitations or restrictions placed on the test item be recorded.

6.1.2 Personnel

a. Ensure that personnel who will operate, maintain, occupy or otherwise utilize the test materiel have been trained using the criteria of MTP 10-3-501, come within the weight and height limits shown in Appendix B and are cognizant of:

1) Pertinent technical publications for the test item.
2) Objectives of the test.
3) Pertinent data required.
4) Method of recording data.
5) Need for reporting all man-machine incompatibilities.
6) Importance of the judgment of military personnel having field experience with similar items.
7) The fact that design of materiel should be commensurate with the skills, aptitudes, and limitations of personnel in tactical situations where the man-machine combination must operate effectively.
8) Possibility of overloading personnel physically and mentally.

b. Record pertinent data of MTP 10-3-501 and the following for all test personnel:

1) Name, rank or grade and military occupational specialty (MOS)

of test personnel.
2) Physical profile of each operator/crewman.

6.1.3 Plan for Collecting Data

Prepare a plan, in outline form as a minimum, for collecting human factors data on each test item for the use of the project officer, using the following guidelines:

a. The depth of coverage will necessarily depend on the degree of complexity of the test item and the time, skills and instrumentation available, and the policies of the test activity.

b. This plan should contain, as a minimum, a list of tasks to be performed or a reference to documents containing these tasks and a human factors engineering checklist.

NOTE: 1. The preventive maintenance tasks to be performed by the operator/crew are described in the operator's manual 10 series, and tasks to be performed by maintenance personnel are described in the 20 and 35 series manuals.
2. Reports of evaluation of operator/crew duties in similar type equipment prepared by the pertinent U. S. Army Human Research Unit may also be useful in that they contain a detailed analysis of each separate operator/crew task and the degree of skill required to perform it satisfactorily.

c. When the QMR or other pertinent document (reference 4B) for the test item contains a section on human factors engineering, it should be used as the checklist. Otherwise, a checklist should be prepared using the sample list in Appendix A and/or references 4C, 4D, 4E, and 4F as guides.

NOTE: The purpose of preparing or documenting a list of tasks to be performed is to ensure that the human factors engineering aspect of each task is given due consideration. A system of checking off each task should be devised. This can be done by placing either an S for satisfactory, MS for marginally satisfactory, or U for unsatisfactory beside each task.

6.2 TEST CONDUCT

NOTE: 1. The determination of man-machine compatibility is a continuous process from receipt of materiel until completion of all testing. It encompasses all aspects of use and maintenance of the equipment, and includes participating personnel from operator/crew to the highest level of maintenance. A few operational tasks involving the use of items such as range finders and turret and gun controls may have specified time and accuracy requirements. The measurement of time and distance, as appropriate, will determine whether these requirements are met. When these requirements are met by an individual or the crew under

ideal or nearly ideal conditions, there are still unanswered questions, e.g., how difficult were the tasks? What effect will mental and/or physical fatigue have on the performance of these same personnel; what will other individuals or crews be able to do under either condition? This emphasizes the need to conduct tests for varying periods of time under different weather conditions using personnel of differing physique. The vast majority of operational and maintenance tasks will not have specified time and/or distance or effort requirements. In service testing, decisions in these areas will usually be based upon experience with similar items under approximately the same conditions.

2. For the purpose of this MTP there are two general types of failures -- equipment failures, and man-related failures. Equipment failures are the result of mechanical, electrical, or chemical malfunction resulting from engineering design or manufacturing deficiencies. These are not related to operator/crew error. Man-related failures are the result of man-item incompatibility, inadequacy of procedural guidance, or insufficient training or orientation of personnel. This MTP is primarily concerned with man-related failures.

Determine the effectiveness and characteristics of the man-test item combination as indicated in test personnel responses to the prepared plan of collecting data (task checklists) of paragraph 6.1.3 and as follows:

a. Throughout all testing, operator/crew (passengers when applicable) should report conditions and/or circumstances which:

1) Adversely affect their comfort or ease of performing any given task.
2) Reduces the effectiveness of the man-machine combination.

NOTE: Special attention should be given to tests such as MTP 2-3-506 (ref 4H) where personnel will be performing assigned in-vehicle tasks (driving, loading and firing weapons, etc.) for sustained periods of time as well as maintenance, resupply of ammunition and fuel, or loading and unloading cargo. Results of testing under these conditions and especially those tasks with a time and/or accuracy criteria should be compared with results obtained under relatively ideal conditions.

b. All reports received should be thoroughly investigated and documented in a manner similar to that shown in Appendix C using the following guidelines:

1) Relate problem areas to either design or psychological and physiological factors.

NOTE: Design relates strictly to the item components such as size of brake pedal, placement of displays and controls, location of access openings, etc. Psychological and physiological factors are related to man-item performance as effected by environmental variables such as noise, temperature, lighting, vibration, force required for lifting or turning, etc.

2) Investigate reports using procedures similiar to that used in trouble shooting mechanical or electrical failures, i.e., began by checking the simplest areas of man-machine incompatibility and proceed to the more difficult areas.

NOTE: For example, if the problem involves adequacy of space, Appendix B can be used to determine whether the weight and body dimensions of the individual making the complaint are within the limits for which the vehicle was designed (in all such cases several individuals of differing physique should perform the task to validate the results) and if they are the investigation should examine complexity of the task or equipment layout which can give the impression of too little room for comfortable operation.

3) Refer problem areas related to health and comfort that cannot be thoroughly diagnosed by the service test activity such as noise levels, noxious fumes, toxicity, vibration, etc., to medical or environmental agencies in accordance with paragraph 3 of reference 4A.

c. Record a description of the action taken to diagnose and resolve each reported problem area by:

1) The test activity
2) Medical or environmental agencies

6.3 TEST DATA

6.3.1 Preparation for Test

6.3.1.1 Safety

Record list of limitations or restrictions, if any, placed on the test materiel by the safety release.

6.3.2.1 Personnel

Record the following:

a. Pertinent data collected as required by MTP 10-3-501.
b. Name, rank or grade and military occupational specialty (MOS) of test personnel.

c. Physical profile of each operator/crewman.

6.3.2 Test Conduct

a. Record the following:

1) Description of each problem area reported that could:

a) Adversely affect personnel comfort
b) Adversely affect ease of performing specific tasks
c) Reduce the effectiveness of the man-machine combination

2) Description of action taken to diagnose and resolve each reported problem area by:

a) The test activity
b) Medical or environmental agencies

b. Retain all checklists submitted

6.4 DATA REDUCTION AND PRESENTATION

All data obtained by inspection, observation, testing, questionnaires should be suitably tabulated or otherwise arranged and presented in a manner to indicate whether the test item meets the criteria in the QMR or other appropriate document.

APPENDIX A

Sample Human Factors Engineering Checklist

1. Entry/Exit

a. Adequate means are provided for ready access to the equipment.

b. All normal entry and exit doors/hatches are free from obstruction, operate easily, and possess the proper means of latching and securing.

c. An adequate alternate emergency exit is provided for armored vehicles.

2. Seats

a. As required, driver and crew seats are adjustable to give proper support and normal operating range to hand and foot controls and vision devices.

b. All seats are as comfortable as practicable.

3. Controls

a. The steering-control/operator-seat relationship permits safe, easy, and comfortable operation.

b. Control sequence requires as few movements as possible.

c. Successive control movements are interrelated, i.e., one movement passes easily into the next.

d. Controls used in rapid sequence have uniform direction of motion.

e. The most important and most frequently used controls are located in the optimum manual areas.

f. Control movements are consistent for all equipments used by a single operator.

g. All primary and emergency controls are easily identifiable both visually and nonvisually.

h. Continuous controls provide operating resistance consistent with performance requirements for speed, accuracy, and smoothness of operation.

i. Discrete controls provide positive stop action such as detents or clicks.

j. All controls can be operated by personnel wearing all clothing prescribed for temperate zone winter conditions.

k. The method used to prevent accidental activation of the control, if

any, does not increase the time required to operate the control to such an extent that it is unacceptable.

l. Activation of the control does not obscure visual display or control markings.

m. The instrument panel is so located that it can be observed from the normal driving position(s).

n. A master warning light or audible signal is activated when engine temperature, oil pressure, etc., are above or below safe operating ranges.

o. Controls such as clutches and foot throttles are located in such a manner that they can be operated easily without the driver having to assume uncomfortable body angles.

p. Foot throttles are so located that the driver, with minimum amount of movement and effort, can remove his foot from the throttle and apply the foot brake.

4. Displays

a. The display can be read easily from normal operator position(s).

b. Information presented is necessary for the decisions or actions required of the operator.

c. Information is presented in the most immediately meaningful form, i.e., no interpretation or decoding is required.

d. Information is displayed to the accuracy required by the decisions or actions of the operator.

e. If scale interpolation is required, it does not introduce a probability for operator errors which are greater than his tasks permit.

f. Information for different types of activities, e.g., operation and maintenance, is not combined unless the activities require the same information.

g. Information is current, that is, lag is minimized.

h. Failure is clearly shown or the operator is otherwise warned.

i. Contrast ratio and illumination of controls and/or displays are sufficient under all expected light conditions.

j. A warning device is provided to indicate operational anomalies, e.g., the emergency brake is on.

5. Miscellaneous

a. Vibration and noise is kept below levels that might impair efficiency of personnel.

b. Ventilation is adequate and the intake or generation of obnoxious or toxic fumes in personnel compartments is avoided.

c. Visibility provides maximum field of view possible in consonance with station, task requirement, and body conformation.

d. Nonskid decking is provided for safety.

e. OEM tools are located where they are easily accessible to operators.

f. Safety seat straps or body harness are provided as required.

. As required, safety straps are strategically placed for ease of access, e.g., safety straps are placed in vehicles that do not have doors on the driver or passenger side, and also are placed in the cargo compartment for the safety of passengers.

h. Portable fire extinguishers are placed at an easily accessible location.

6. Maintainability Design

a. Covers, Cases, and Access Doors

1) Hinges are used, where possible, to reduce the number of fasteners required.

2) Structural members or other components do not interfere with removal of a cover.

3) Provision is made for adequate bonding of plastic or rubber stripping and seals so that if a cover comes into contact with, or must slide over such material, the seal will not be damaged or the cover jammed.

4) Where feasible, guides, tracks, and stops are provided to facilitate handling and to prevent damage to components.

5) Hinged doors or covers are provided with captive, quick opening fasteners.

6) The number and type of fasteners must be commensurate with the need for compensation of stress, bonding, etc.

7) When possible, the size and type of fasteners used for all covers, cases, and access doors are the same.

8) Maximum use is made of tongue-and-slot catches to minimize the number of fasteners required.

9) Captive nuts and bolts are used where feasible.

10) Access doors are hinged at the bottom, if possible. When access doors must be hinged at the top, a support rod is provided to hold the cover open. Hinged doors or covers are provided with captive quick-opening fasteners.

11) If instructions applying to a covered unit are lettered on a hinged door, the lettering is properly oriented for reading when the door is open.

12) Hand-operated fasteners are preferred; those requiring standard hand tools are acceptable; fasteners requiring nonstandard tools should not be used.

b. Accessibility

1) Information placed at each access includes the nomenclature of accessible items and warnings of hazardous or critical operations.

2) Edges of accesses have internal fillets or other protection if they might otherwise cause injury to hands or arms.

3) Access provisions are located on easily accessible surfaces.

4) Components are placed neither in recesses nor behind or under stress members, floor boards, seats, hoses, pipes, or other items which are difficult to remove.

c. Location of Replaceable Components

1) Large components which are difficult to remove are mounted so that they do not prevent access to other components.

2) Components are located so that each replacement unit can be removed through a single access panel.

3) Components are placed to allow sufficient space for use of test equipment and other required tools without difficulty or hazard.

4) All throwaway components are accessible without removal of other components.

5) Structural members of the chassis do not prevent access to component.

6) Delicate components are so located or guarded that they will not be damaged while the unit is being handled or repaired.

7) Components are located so that blind adjustments are not necessary.

8) Components of the same or similar form, such as seals, are mounted with a standard orientation throughout, but are readily identifiable and distinguishable.

9) Equipment is modularized so that rapid and easy removal and replacement of malfunctioning modules or components can be accomplished by one technician.

10) Components can be checked and adjusted separately and then connected together into the system with minimum adjustment.

d. Component Mounting

1) Whenever possible, components are located so that no other equipment must be removed to gain access to or remove the components.

2) If it becomes necessary to place one component behind another, the component requiring less frequent access is placed in the rear.

3) Components frequently removed from their normal installed position for checking are mounted on rollout racks, slides, or hinges.

4) Limit-stops are provided on rollout racks and drawers; override of these limit stops is easily accomplished.

5) Field removable components are replaceable with common handtools.

6) Components are mounted to the housing rather than attached to each other so that only the component to be replaced has to be removed.

7) Removal of any replaceable component requires opening or removal of a minimum number of covers or panels (preferable one).

8) Components are laid out so that a minimum of place-to-place movement by the operator is required during checkout.

9) Components are located and mounted so that access to them may be achieved without danger to personnel, e.g., from electrical charge, heat, sharp edges and points, moving parts, chemical contamination.

10) Access to units maintained by one operator do not require removal of equipment by a second higher-skilled operator.

e. Conductors, Cables, and Conduits

1) Long conductors, cables, and conduits internal to equipment are secured to the chassis by cable clamps.

2) Cables are long enough so that each functioning component can be checked in a convenient place or, if this is not feasible, extension cables are provided.

3) Cables are long enough to permit jockeying or moving components when it is difficult to connect or disconnect other cables.

4) Cables and conduits are routed so they cannot be walked on or used for handholds.

5) Cables and conduits are easily accessible for inspection and repair.

6) Cables and conduits are so routed that they need not be bent or twisted sharply or repeatedly.

7) If feasible, individual conductors of all cables are color-coded their entire length.

f. Connectors

1) One-turn or other quick disconnect plugs are used.

2) When dirt and moisture are a problem, plugs have an attached cover.

3) Connectors are located far enough apart so they can be grasped firmly for connecting and disconnecting.

4) Rear of plug connectors is accessible for test and service, except where this is precluded by potting, sealing, etc.

5) Plugs or receptacles are provided with aligning pins or other alignment devices.

6) Plugs so designed that it is impossible to insert them in a wrong receptacle.

7) Socket, rather than plug, contacts are "hot".

8) Connectors and their associated labels are positioned for full view by maintenance personnel.

9) Connecting plugs and receptacles are identified by color or shape or other acceptable means.

10) Plugs and receptacles have painted stripes, arrows, or other indications to show proper insertion of aligning pins.

g. Test Points

1) Test points to determine that a unit is malfunctioning are provided.

2) Appropriate test points are provided when a component is not completely self-checking.

3) Lower maintenance categories test points located and coded so they are readily distinguished from higher maintenance categories test points.

h. Fuzes and Circuit Breakers

1) Fuzes and circuit breakers so located that they can be seen easily and replaced or activated quickly.

2) Fuze replacement is not hampered by other components.

3) No special tools are required for fuze replacement.

i. *On Equipment Tools*

1) Variety of tools is held to a minimum.

2) As few special tools as possible are required.

3) Tools are of dull finish to avoid glare in strong light.

4) Speed and ratchet-type tools are provided when necessary.

5) Shock-proof tools are provided when required.

j. Lubrication

1) Equipment containing mechanical components either has provision for lubrication without disassembly or does not require lubrication.

2) When lubrication is required, the type of lubricant and the frequency of lubrication is specified on a nearby label.

APPENDIX B

Clothed Body Weight and Dimensions[a]

	Percentiles 5th	95th
1. Weight (pounds)	141.9	210.2
2. Dimensions (inches)		
Height	67.8	75.8
Sitting height	35.1	39.4
Shoulder height, sitting	21.4	29.3
Shoulder breadth	16.7	19.6
Bi-acromial	-	-
Chest breadth	11.0	13.6
Chest depth	8.4	10.8
Buttock depth	7.6	10.2
Hip breadth, standing	12.6	15.0
Elbow breadth	15.7	20.4
Hip breadth, sitting	13.2	16.0
Span	65.9	75.6
Maximum reach from wall	35.4	41.7
Forearm-hand length	17.6	20.2
Shoulder-elbow length	13.2	15.4
Elbow-center of fist	-	-
Buttock-knee length	21.9	25.4
Knee height	20.1	23.3
Eye height, sitting	29.4	33.5
Knee-to-knee breadth	7.2	8.8
Interpupillary distance	2.3	2.7
Hand breadth	3.2[b]	3.7[b]
Hand length	6.9[b]	8.0[b]
GI shoe length	11.0	12.7
GI shoe width	4.0	4.5

[a] Soldiers wearing basic Khaki, Olive Drab or Fatigue uniforms with summer underwear, socks, shoes, helmet, and liner. Additional data including nude dimensions are shown in HEL Standard S-2-64 (reference 4E of basic MIP)

[b] Without gloves

APPENDIX C

Sample of General Information Questionnaire

Date _____

Name _____, Rank or Grade _____, MOS _____

Nomenclature of Equipment _____

Duty Station (Driver, Gunner, etc.) _____

Type of Uniform: (Check one): Summer ____ Winter ____ Arctic _____

Briefly describe nature of complaint:

Weather and Light Conditions (circle one or more that apply):

Cold Very Cold Hot Very Hot Humid Rain Snow Cloudly Fog

Mist Night Day Sunshine Overcast Moonlight Starlight

Number of hours continuously on duty at time discrepancy was noted. _____

How long had you been performing the specific task where discrepancy was noted. _____

Were you feeling well at beginning of duty period? Yes____ No ____
Were you feeling well at time discrepancy was noted? Yes____ No ____

If NO was checked for either question, describe condition, e.g., tired, sleepy, headache, slight cold, etc.

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13. ABSTRACT

This Army Service Test Procedure describes test methods and techniques for evaluating the human factors engineering characteristics of tactical military equipment, and for determining their suitability for service use by the U. S. Army. The evaluation is related to criteria expressed in applicable Qualitative Materiel Requirements (QMR), Small Development Requirements (SDR), Technical Characteristics (TC), or other appropriate design requirements and specifications.

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